

gether disagreeable. Fig. 5 shows exactly the stiff attitude the head is compelled to take in order to rest.

Finally, Fig. 6 reproduces the comfortable position indicated in Fig. 3, and at the same time represents the profile of the back of the seat actually in use in our railway carriages. On comparing this profile with the position of the man comfortably supported, the following defects in the back of the seat are observed:—

1. It is too vertical.
2. It allows an empty space between the lumbar vertebrae and the lower extremity of the shoulder-blade exactly at the place where one is in the habit of putting a cushion "behind the back," as it is called.
3. It is at least half a foot too high, and so makes it impossible for the head to rest behind. It is customary to make the back of the seat tally with the height of a man of average size seated bolt upright.

Under the actual conditions, such as they have been

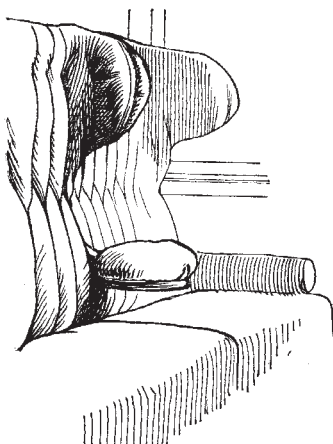


FIG. 9.

described, what becomes of the traveller when sleep at length overtakes him? Little by little he slides down on his seat till the lower extremity of his shoulder-blades, which has most need of support, finds the most sensible projection, which, as the backs of our railway carriages actually are, is precisely where it is least serviceable—at a point, namely, on a level with the region of the pelvis. Lastly, the head inclines forward or to the side, if it does not bury itself in the breast (Fig. 7).

Fig. 8 gives a front view of the face of the bench serving as the back of the seat. In the centre is seen a stuffed projection, on each side of which a passenger may rest his cheek. The shoulder, getting no separate support, must contrive to lodge itself between this stuffed projection and a kind of plateau fixed in the side of the back of the seat, and which, situated about a hand's breadth above the seat, offers a resting-place to the elbow (Figs. 8 and 9).

A NEW PRINCIPLE OF MEASURING HEAT

THE following method is intended to fulfil some conditions which probably will be more and more urgently required in the progress of modern science:—

1. *Measurements of heat should be executed at constant temperature, i.e. without the aid of thermometers.*—Every variation of temperature during calorimetric experiments causes unavoidable errors and necessitates corrections and compensations. The accuracy of the thermometric method ["method of mixture," of Regnault], which now predominates among experimentalists is unrivalled, only in those cases where the amount of heat to be measured is developed in the course of a few seconds or minutes; it is seriously impaired whenever the experiment lasts longer, while the

influence of the corrections for radiation, &c., increases proportionately with the duration of the operation. The first method used in thermo-chemical investigations, the ice-melting method of Lavoisier and Laplace, as well as the modern calorimetric method by Bunsen, avoids this inconvenience by executing all measurements at the melting-point of ice. Bunsen's ice calorimeter is, however, not exempt from corrections. Every physicist familiar with the use of this instrument will also, like the author, be well acquainted with its capriciousness. Bunsen prescribes that the calorimeter should be placed in a large vessel filled with absolutely pure snow. Although I have had abundant quantities of the purest snow at my disposal, I do not hesitate to declare, having tried, in company with Prof. Nilson, a whole winter to obtain reliable results with the original arrangement of the inventor, that the instrument would be impracticable for use without the improvement devised by Schuller and Wartha, viz. to immerse the calorimeter in a vessel containing ice and pure water at 0°C . Still the advantage of this arrangement is not to prevent variations in the position of the mercury index, but to make them quite *regular*. These variations are declared by some physicists to depend upon the vacillation of atmospheric pressure, but I think that the real

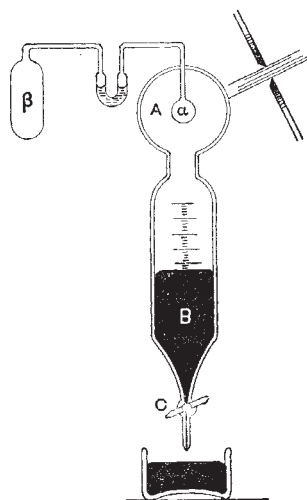


Fig. 1

cause of the unsteadiness of the index of the instrument lies in the peculiar behaviour of the ice in the vicinity of its melting-point. It was believed hitherto (and Bunsen's method theoretically rests upon this assumption) that ice at 0°C . suddenly changes its specific volume from that of ice [= 1.090686]¹ to that of water [= 1.000000]. I admit that this assumption may be true with regard to *absolutely pure ice*, but in every kind of frozen water which contains the smallest trace of impurity (which is unavoidable if the water has been boiled assiduously in a glass vessel) the transition of ice into liquid water is not sudden, but gradual, and *begins already a little below 0°C* . Such ice does not attain its maximum of volume exactly at 0°C , but some hundredths or tenths of a Centigrade degree below 0° (dependent upon its relative purity). Graphic representation² shows that the co-ordinate of specific volume of the ice comes not to a *point d'arrêt* at zero, but moves upon the rapidly-sloping branch of a curve just in the immediate vicinity of the melting-point. Now suppose the water in the external vessel to be either a little purer than that of the calorimeter, or *vice versa*. In the

¹ This number, which is almost identical with that of Bunsen, was found by the author in his research "Upon the Properties of Water and Ice," "Vega-expeditionens vet. iakttagels." Bd. ii. p. 275.

² See the paper "Upon Water and Ice," by O. Pettersson, *z.c.*

former case its temperature, *i.e.* its melting-point, will be situated a few thousandths of a Centigrade higher, and the volume of the ice in the calorimeter will move down-

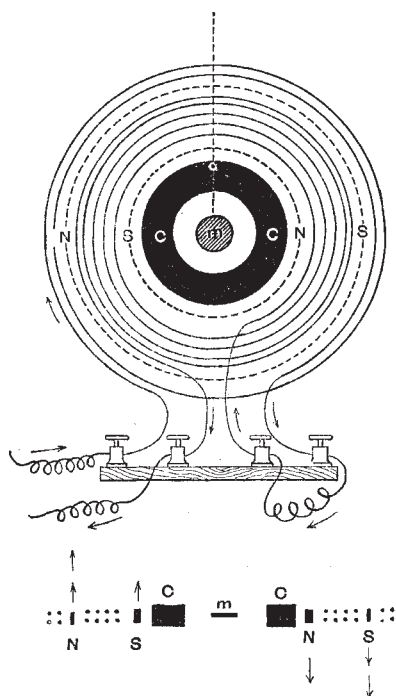


Fig. 2

wards on the branch of the curve in the attempt to gain the temperature of the surrounding medium. Then the index will move slowly backwards; in the other case the co-ordinate of specific volume will move upwards on the

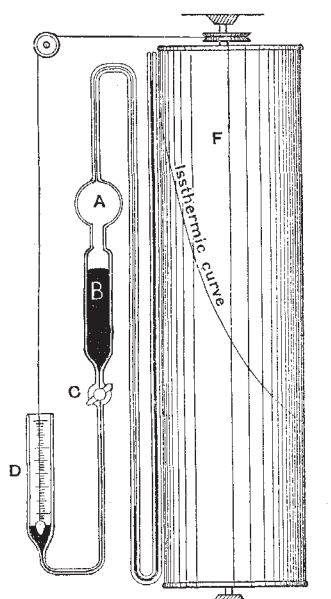


Fig. 3

sloping branch, and the index of the scale-tube will march forwards. These remarks may be sufficient to explain why there has been much dispute about the absolute

magnitude of the caloric units indicated by the ice calorimeter of Bunsen, and why this instrument is always *empirically* graduated, although its principle ought to allow of *absolute* measurements.

II. *The amount of heat developed in calorimetric experiments should be directly transformed into work and measured in absolute units [kilogramme-metres].*¹—In every branch of physical science this manner of measurement is beginning to introduce itself, as, for example, in electricity, magnetism, &c. In thermal determinations it has the great advantage that the mechanic units are 430 times greater than the thermic units, and can be far more accurately determined.

III. *The principle should be applicable to the measurement of all kinds of caloric energy: as, specific heat, radiant heat, the heat absorbed or developed by chemical reactions, &c.*—It must be remarked that I have hitherto experimented only with *radiant heat*. An apparatus intended for other kinds of heat is under construction,

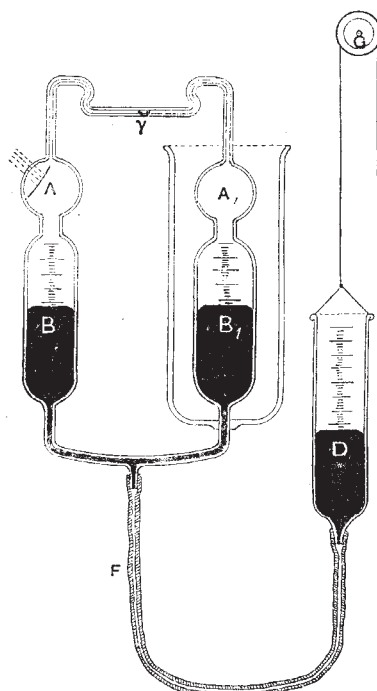


Fig. 4

but as this will take some time, and as I wish specially to direct my labour to the determination of the sun's radiant heat, I take the opportunity now of calling the attention of physicists to the principle of the method, which I foresee can be developed and varied in a multitude of ways. In case the matter should interest anybody sufficiently to make him try it experimentally, I will give some information in order that he may not be detained by those difficulties which have baffled my own efforts during nearly six years. The principle is extremely simple, and will be easily understood by a glance at the diagram (Fig. 1).

Let a beam of heat rays fall upon the thin glass wall of the reservoir A, which contains dry air. As soon as the thermometer *aβ* indicates that the temperature of the air in A *increases*, let mercury escape through the stopcock C. Thereby the air *expands*, and the heat received by radiation is transformed into mechanic work, as the level of mercury in B sinks under the influence of the expanding force imparted to the air by the radiant heat.

¹ I denote this in the following by the sign M:K°.

As the air in A in this case has expanded *isothermically*, the mechanic work is represented by the equation

$$x = p_0 v_0 \log_{\text{nat}} \frac{v}{v_0},$$

where p_0 v_0 are the initial pressure and volume of the air in A, and v is its volume after the expansion. If we suppose that a beam of sun rays during a minute has fallen upon the blackened surface of A through a hole of a square centimetre, and that the experimenter has neutralised the tendency of the air to increase in temperature by careful manipulation of the stopcock C, which allows the air to expand its volume as it displaces the escaping mercury—suppose that in this way the cooling effect of the expansion has neutralised the tendency of the air to augment its temperature under the influence of the heat radiation, so that the index of the thermometer has been kept *constantly* at its initial point, then the *entire* amount of solar heat imparted to the glass reservoir A is converted into mechanic work by means of the isothermic dilatation of the air, and the value of x found by the above equation represents what is called by modern scientists “the solar constant.”¹

It is obvious that the chief difficulty lies with the thermometer. The indications of this part of the instrument must be *extremely sensitive* (up to some thousandths of a degree Centigrade) and *instantaneous*, in order that the experimenter may be able to regulate the expansion so that a real isothermic dilatation takes place. I judged that only two kinds of thermometers could suit the purpose, and tried first a differential glass thermometer. This is in fact very sensitive, but as the pressure in A diminishes during the experiment, the bulb α expands somewhat, and this has a disturbing influence upon the index. I next inserted in A a network of very thin thermo-electric elements (combinations of iron and German silver), and observed the alterations of temperature of the air in A by means of a mirror galvanometer. As I found the ordinary system of magnets in galvanometers far too heavy for the instantaneous deflections here required, I constructed a new kind of galvanometer, whereof I give a schematic view in Fig. 2, because I think that it may really do some good work in other cases, as it proved to be extremely sensitive. The dotted lines represent a system of two concentric (annular) magnets made of steel springs (from watches), each magnetised to saturation between the poles of a powerful Plücker electro-magnet. They are combined in the astatic manner, but the dimensions of the material are chosen so that the *inner* magnet has just sufficient force to keep the whole system in the magnetic meridian. The figure shows the position of the insulated copper wires relatively to the magnets. M is a mirror of very thin silvered glass; C C is a massive copper ring. I tested the sensibility of the instrument by adiabatic expansion of the air in A. This was effected by opening the stopcock C for a moment. The slightest dilatation of the air in this manner immediately showed its cooling effect by a deflection of the scale in the mirror, but as the deflection soon brought the magnets out of the electric field, the *amplitude* of the oscillation was, as I had calculated, not great. However, as the oscillations did not cease instantaneously, I found the method impracticable for *continuous* observation. I then abandoned the project of regulating the isothermic expansion *by means of a thermometer* altogether.²

The next arrangement, which succeeded better, was that shown in Fig. 3. Here the co-ordinates of the isothermic curve are traced out beforehand on the rotating cylinder F. As the mercury in B flows into D, it lifts a float, which, by a combination of wire and blocks,

makes the cylinder rotate at a rate which is proportional to the expansion of the volume of the air in A. Thus the horizontal co-ordinate (v) of the isothermic curve is represented. The vertical co-ordinate of the pressure of the air in A (p) is represented by the height of the liquid in the open branch of the manometer. The operator only has the task to regulate the outflow of the mercury from B to D by means of the stopcock C, so that the level of the fluid in the manometer closely follows the isothermic line drawn upon the paper envelope of the rotating cylinder. This is not difficult after a little experimenting. Whenever the level in the manometer shows a tendency to rise above the isothermic line, there is a surplus of heat in A waiting for transformation into work, which can be effected by accelerating the outflow of the mercury through C. The area contained between the initial and final ordinates [p_0 and p , represented by the positions of the column of liquid in the manometer-tube relatively to the cylinder at the commencement and the close of the experiment] represents the value of the integral—

$$p_0 v_0 \int_{v_0}^v \frac{dv}{v}$$

or the amount of mechanic work equivalent to the transformed caloric energy. Thereby this method affords an elegant manner of showing the actual transformation of all kinds of heat into work to an auditory. In order to obtain indications on a grand scale I always used H_2SO_4 tinted blue with indigo in the manometer. The rotating cylinder is about 2 m. high, and a quantity of heat of not more than 876 gramme-calories, imparted by radiation or otherwise to the air in A, makes the cylinder rotate 360° , and the level of the liquid in the manometer sink 1.84 m.¹ The volume of A was 400 c.c., and the initial pressure equal to 1000 mm. (of mercury). But for scientific measurements I cannot recommend this method. The sulphuric acid *adheres* to the glass tube, and does not take up its definitive level *at once*, the dimensions of the apparatus become inconveniently large, the co-ordinate p cannot be traced out on the paper of the cylinder directly from the isothermic equation,

$$pv = RT_0,$$

but must be recalculated with the aid of some corrections arising from the influence of the atmospheric pressure upon the columns of liquid in the manometer and in D, too complicated to be mentioned here.

Fig. 4 shows a kind of calorimeter which realises the condition of isothermic dilatation of the air in the most simple manner and still is capable of the most accurate measurements.

A and A_1 are very thin glass vessels fabricated of equal shape and size by Franz Müller in Bonn. Both contain dry air over mercury, which stands at equal height in B and B_1 . If the graduated glass tube D, which communicates with A and A_2 through a caoutchouc tube, is raised or lowered by means of the arrangement shown in the figure, the level of the mercury rises or sinks equally in B and B_1 , and the air in A and A_1 is compressed or dilated equally, provided that the temperature is kept *constant* in both. This condition is realised in A_1 by the surrounding large mass of water, which imparts to the air and mercury in A_1 and B_1 its own constant temperature. The air in A_1 therefore always expands or contracts isothermically. If its initial volume and pressure are denoted by v_0 and p_0 , the law of Mariotte,

$$vp = v_0 p_0,$$

will always regulate the expansion of the air in A_1 . It is easy to see that this will also be the case in A, if the experi-

¹ Uncorrected.

² I think the thing will be very difficult to realise in this way. If another indicator could be substituted for the galvanometer, for example, the Lippmann capillary electrometer in the ingenious form devised by Chr. Lovén, the experiment would be very easy. But, unhappily, this instrument is insensible to thermo-electric currents.

¹ *i.e.* theoretically. This height is somewhat reduced by the corrections for the pressure, &c.

ment is conducted so that during the dilatation of the air in A and A_1 the index of the differential thermometer γ , which combines both instruments, is kept constant. Suppose then a beam of heat rays to fall upon a thin piece of platinum foil¹ in A *through the glass wall*. The immediate effect of radiation is to elevate the temperature of the air in A, but as an increase of only 0.0016 of a centigrade causes a displacement of the differential index γ of 1 mm.,² it is easy for the operator to compensate this tendency and transform the heat into work by lowering the graduated tube D, which makes the air in A and A_1 expand. This expansion is *isothermic* in both, because volume and pressure varies in the same way in A as in A_1 , where it, as shown formerly, follows Mariotte's law.³ The rate of expansion of the air is indicated by the rise of the mercury in the calibrated tube D. The sensibility of the differential index is so great that it requires a very steady hand to regulate the movement of D so that the index keeps constantly at its initial point, without making greater excursions to either side than 1 or 2 mm. Every irregularity in the movement changes the isothermic expansion into adiabatic dilatation or compression. I therefore prefer to regulate the sinking of D by means of a screw. During the experiment A must be protected by isolating screens, &c., from outward disturbing thermal influences. I think I have realised this in a satisfactory way, but as a detailed account of the arrangement would be too long, I must reserve the complete description for a future paper.

Lastly I will mention some examples of determinations of the radiant heat emitted by a regulation gas-burner at 22.5 cm. distance from A. The radiation was admitted through a screen with an opening of $4\frac{1}{2} \times 2\frac{1}{2}$ cm. The initial volume of the air in A^4 was 622.22 c.c. The pressure was brought to 760 mm. Experiment I. was made at noon, II. in the afternoon of the same day.

Experiment I.—Increase of volume by expansion during 6 minutes = 185.9 c.c. Mechanical equivalent of the radiation during 6 minutes = 1.680 M.K°. Mechanical equivalent of the radiation during 1 minute = 0.280 M.K°.

Experiment II.—Increase of volume, &c., during 5 minutes = 158.5 c.c. Mechanical effect of radiation in 5 minutes = 1.459 M.K°. Mechanical effect of radiation in 1 minute = 0.291 M.K°.

I have measured in this way the mechanical effect of radiations, the caloric energy of which was only 0.08 of a gramme-calorie in the minute. *This method is free from every kind of correction.* It is obvious that, by means of a thin test-tube hermetically inserted into A, calorimetric determinations of specific heat, &c., could be made, but I have not yet arranged the apparatus for this purpose.

OTTO PETTERSSON

Stockholms Högskolas Laboratorium, June 25

NOTES

THE Government have directed Dr. Klein, F.R.S., and Dr. Heneage Gibbes, to proceed to India to pursue a scientific inquiry into the nature of cholera. It is understood that these gentlemen will act in conjunction with the Commission nominated a few weeks ago by the Indian Government for the same object.

At the meeting of the Council of the Marine Biological Association on Friday, July 25, Prof. Moseley in the chair, the names

¹ It is blackened in the following way. It is galvanically coated with a thin layer of metallic copper, and afterwards heated in a current of oxygen. This arrangement gives most sensitive indications.

² This is the case in the apparatus constructed by the author. The index there consists of a small drop of coloured alcohol. If H_2SO_4 is substituted for the alcohol, the sensibility of the apparatus is lessened considerably.

³ In my last constructed apparatus I have substituted a vessel of thin copper instead of the upper part of the glass vessel A_1 . This arrangement answers the purpose excellently.

⁴ And also in A_1 , which is of the same size. This condition is, however, by no means indispensable. A_1 can be greater or smaller than A, only the dimensions of A and A_1 , B and B_1 are proportional to each other.

of Prof. Allman, F.R.S., and Sir John St. Aubyn, Bart., M.P., were added to the list of Vice-Presidents, and Mr. Spence Bate of Plymouth was elected on the Council. It was decided that, provided certain arrangements promised by a committee of the Town Council of Plymouth were carried out, the Association should proceed to erect its first laboratory on Plymouth Sound. Plymouth is not only the best position for the laboratory on account of its natural features, but the local committee has offered to the Association a free site on the seashore and a subscription of 1000*l*. A vote of thanks to H.R.H. the Prince of Wales for having become the Patron of the Association was carried. The financial prospects of the Association were reported as highly satisfactory. The building of the laboratory will probably be commenced in the spring.

THE eighth International Medical Congress is to be held in Copenhagen from August 10 to 16. President, Prof. Dr. P. L. Panum; Secretary, Dr. C. Lange, both of Copenhagen. Among the most eminent of the 658 medical men who have engaged to attend are:—Prof. Lister, Sir William Gull, Bart., Prof. Dr. L. Pasteur, Prof. Paul Bert, and Prof. Dr. R. Virchow.

THE Congress of the British Medical Association opened in Belfast on Tuesday. Prof. Canning directed his presidential address mainly to an analysis of the origin and causes of the spread of epidemic diseases.

THE prospectus has just been issued of the new "Società di Geografia ed Etnografia," founded in Turin in anticipation of the Italian Geographical Congress, which meets in that city on August 15. The Congress is a passing event, but the Society has probably a brilliant career before it, established as it is under the auspices of Prof. Guido Cora, its first President. The well-known *Cosmos* of the distinguished geographer becomes the authorised scientific *Journal* of the Society, a happy arrangement which cannot but prove mutually beneficial. In other respects everything is for the present provisional, and the council, including besides Sig. Cora such names as those of Luigi, Schiaparelli, Enrico Morselli, and Alessandro di Cesnola, holds office only till the beginning of next year, when the statutes will be definitely settled, and a permanent administration established. Meantime it is satisfactory to find that ethnology, a branch of geographical science so strangely neglected by existing geographical institutes, is to receive all due prominence and encouragement. Another important feature is the attention to be paid to commercial and industrial geography, especially as regards Italy in its relations with foreign countries. This idea also, *mutatis mutandis*, might be advantageously adopted by similar learned bodies elsewhere.

THE *Bollettino* of the Italian Geographical Society for July publishes the circular, regulations, and programme of the first Italian Geographical Congress, which meets in Turin from the 15th to the 19th of next August under the presidency of the President of the Italian Geographical Society. All except honorary members to be specially named will be expected to contribute towards the expenses sums varying from ten to thirty francs. In return they will have free access to all the scientific gatherings, and will be entitled to a copy of the *Proceedings* of the Congress. There will be two Sections—a Scientific and Commercial, and questions will be discussed in connection with mathematical, physical, ethnographic, political, economic, and historic geography. Amongst the subjects proposed for discussion are the following:—"What ethnological conclusions are to be drawn from the more recent anthropological and philological data, regarding the indigenous populations of East Africa?" "Considering the part already taken by Italy in scientific exploration in the Polar seas, what are the best means of organising an independent Italian expedition to the Antarctic regions?" "On the need of preparatory schools for training